

order of magnitude the power typically obtained from a conventional geothermal well in Iceland. The aim of the IDDP is to determine whether utilization of heat from such an unconventional geothermal resource at supercritical conditions will lead to increased productivity of wells at a competitive cost. If the IDDP is an economic success, this same approach could be applied in other high-temperature volcanic geothermal systems elsewhere, an important step in enhancing the geothermal industry worldwide.

06/00868 Thermodynamic analysis of a ground-source heat pump system for district heating

Hepbasli, A. *International Journal of Energy Research*, 2005, 29, (7), 671–687.

This study deals with the thermodynamic analysis of ground-source heat pump (GSHP) systems for district heating. The mass, energy, entropy and exergy balance relations are derived and applied to a GSHP system with a U-bend ground heat exchanger. The performance characteristics of this GSHP system are evaluated in terms of energetic and exergetic aspects. Based on the measurements conducted on 7 January 2004, the heat extraction rate from the soil is found to be, on average, 61.4 W m^{-1} of bore depth, while the required borehole length in meter per kW of heating capacity is obtained as 11.71. The entering water temperature to the unit is measured to be 15.3°C . The heating coefficient of performance of the heat pump (COP_{HP}) is about 2.85, while that for the whole system is obtained to be 7.4% lower than COP_{HP} . The exergy efficiency values for the heat pump unit and whole system are found to be 66.8 and 66.6%, respectively.

Solar energy

06/00869 Are new institutional economics enough? Promoting photovoltaics in India's agricultural sector

Radulovic, V. *Energy Policy*, 2005, 33, (14), 1883–1899.

Solar photovoltaic (PV) technology can bring emissions-free electricity to rural areas without access to the grid. Currently, policymakers are seeking ways to expand markets for off-grid PV from solar home systems to productive uses in order to enhance income generation and contribute to social development. This paper explores the role of the state in promoting such market growth. As a start, the state must improve institutions, thus echoing popular recommendations based in new institutional economic theory (NIE) that are currently touted by the World Bank and other large development agencies. Yet, NIE's framework may be insufficient because it fails to offer viable solutions to overcoming political barriers that contribute to technological path dependency. A case study in Punjab, India, where an agricultural PV water pumping program showed promising signs of successful market penetration in its first 3 years of operation, illustrates how the NIE's shortcomings manifest themselves in practice. The program was beginning to penetrate market entry for PV pumps via competition between PV providers. However, the government of India achieved this feat by providing subsidies to wealthy farmers, a move that is frowned upon by the NIE school. Based on findings from the case study, states should look beyond NIE's framework to expand and improve PV markets in productive uses by accounting for political constraints, assessing how PV technology can improve development goals, and cultivating locally appropriate service delivery models.

06/00870 Design consideration of low temperature differential double-acting Stirling engine for solar application

Abdullah, S. *et al. Renewable Energy*, 2005, 30, (12), 1923–1941.

This paper presents design considerations to be taken in designing of a low temperature differential double-acting Stirling engine for solar application. The target power source will be a thermosiphon solar water heater with integrated storage system, which will supply a constant source temperature of 70°C . Hence, the system design is based on a temperature difference of 50°C , assuming that the sink is kept at 20°C . During the preliminary design stage, the critical parameters of the engine design are determined according to the Schmidt analysis, while the third order analysis was used during the design optimisation stage in order to establish a complete analytical model for the engine. The heat exchangers are designed to be of high effectiveness and low pressure-drop, and are made from a 0.015 m tube, while the porosity of the steel wool of 0.722 is used for the regenerator matrix. Upon optimisation, the optimal engine speed is 120 rpm with the swept volume of 2.3 l, and thus the critical engine parameters are found to be the bore diameter of 0.20 m. In addition, the volumes of heater, cooler and regenerator are 1.3 l, 1.3 l and 2.0 l volumes, respectively.

06/00871 Effect of relative humidity on solar potential

Sözen, A. and Arcaklioglu, E. *Applied Energy*, 2005, 82, (4), 345–367. In this study, the effect of relative humidity on solar potential is investigated using artificial neural-networks. Two different models are used to train the neural networks. Meteorological and geographical data (latitude, longitude, altitude, month, mean sunshine-duration, and mean temperature) are used in the input layer of the network (Model 1). But, relative humidity values are added to one network in data in (Model 2). In other words, the only difference between the models is relative humidity. New formulae based on meteorological and geographical data, have been developed to determine the solar energy potential in Turkey using the networks' weights for both models. Scaled conjugate gradient (SCG) and Levenberg-Marquardt (LM) learning algorithms and a logistic sigmoid transfer-function were used in the network. The best approach was obtained by the SCG algorithm with nine neurons for both models. Meteorological data for the four years, 2000–2003, for 18 cities spread over Turkey have been used as data in order to train the neural network. Solar radiation is in output layer. One month for each city was used as test data, and these months have not been used for training. The maximum mean absolute percentage errors (MAPEs) for Tosya are 2.770394% and 2.8597% for Models 1 and 2, respectively. The minimum MAPEs for Seydisehir are 1.055205% and 1.041% with R^2 (99.9862%, 99.9842%) for Models 1 and 2, respectively, in the SCG algorithm with nine neurons. The best value of R^2 for Models 1 and 2 are for Seydisehir. The minimum value of R^2 for Model 1 is 99.8855% for Tosya, and the value for Model 2 is 99.9001% for Yenisehir. Results show that the humidity has only a negligible effect upon the prediction of solar potential using artificial neural-networks.

06/00872 Experimental testing of a box-type solar cooker using the standard procedure of cooking power

El-Sebaei, A. A. and Ibrahim, A. *Renewable Energy*, 2005, 30, (12), 1861–1871.

A box-type solar cooker with one (Model I) or four (Model II) cooking pots was constructed and tested under Tanta prevailing weather conditions. Experiments were performed during July 2002 using the cooker with or without load. The obtained results were employed to calculate the two figures of merit, F_1 and F_2 , as well as the utilization efficiency η_u and the specific t_s and characteristic t_c boiling times. The obtained values of F_1 indicate that the cooker can be used twice a day for consecutive cooking. F_2 was found to increase almost linearly with the mass of the cooking fluid M_f . The cooker is able to boil 1 kg of water in 15 min when its aperture area equals 1 m^2 . Furthermore, experiments also considered the requirements for the international standard test procedure for solar cookers. The cooking power P was correlated with the temperature difference ΔT between the cooking fluid and the ambient air. Linear correlations between P and ΔT had correlation coefficients higher than 0.90 satisfying the standard. The obtained values of the initial cooking power, heat loss coefficient and the cooking power at a temperature difference of 50°C agree well with those obtained for small solar cookers. The present cooker is able to cook most kinds of food with an overall utilization efficiency of 26.7%.

06/00873 Further developments in CIS monograin layer solar cells technology

Altosaar, M. *et al. Solar Energy Materials and Solar Cells*, 2005, 87, (1–4), 25–32.

This paper reviews recent studies and technological developments on different materials and technologies for monograin layer (MGL) photovoltaics (PV) solar cells conducted at Tallinn University of Technology. It is shown that in spite of improvements in technical parameters of MGL solar cells resulting from research in adsorber layer materials and surface modification, several problems have to be solved before determining the prospects of design.

06/00874 Heat-transfer enhancement in double-pass flat-plate solar air heaters with recycle

Ho, D. C. *et al. Energy*, 2005, 30, (15), 2796–2817.

This work theoretically and experimentally investigates a device for inserting an absorbing plate into the double-pass channel in a flat-plate solar air heater with recycle. This method substantially improves the collector efficiency by increasing the fluid velocity. The results are represented graphically and compared with a downward-type single-pass solar air heater. Considerable improvement in heat transfer is obtainable by employing recycle-type double-pass devices instead of single-pass devices or a conventional double-pass heater with the same flow rate. The absorbing plate location influence on heat-transfer efficiency enhancement and the hydraulic dissipated power increment is also discussed.

06/00875 Minority carrier lifetime in plasma-textured silicon wafers for solar cells

Kumaravelu, G. *et al. Solar Energy Materials and Solar Cells*, 2005, 87, (1–4), 99–106.